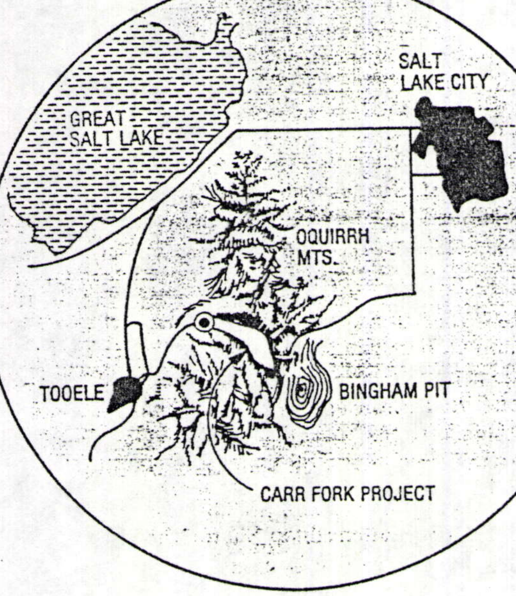
CARR FORK: NEW MINE, OLD DISTRICT

ANACONDA PLANS 1979 START AT A MODERN UNDERGROUND COPPER MINE IN UTAH'S HISTORIC BINGHAM DISTRICT

Dan Jackson, Western editor



Modern mining methods and equipment, a gravity-based concentrator flow that will require only five process pumps, and metric design are the highlights of The Anaconda Co.'s Carr Fork project in Utah, where production is scheduled to begin in late 1979. The 12,700-mtpd mine will feed copper ore grading 1.84% Cu to a 9,000-mtpd plant, with full production to be reached about a year after startup. Byproduct credits will include molybdenum, gold, silver, and magnetite.

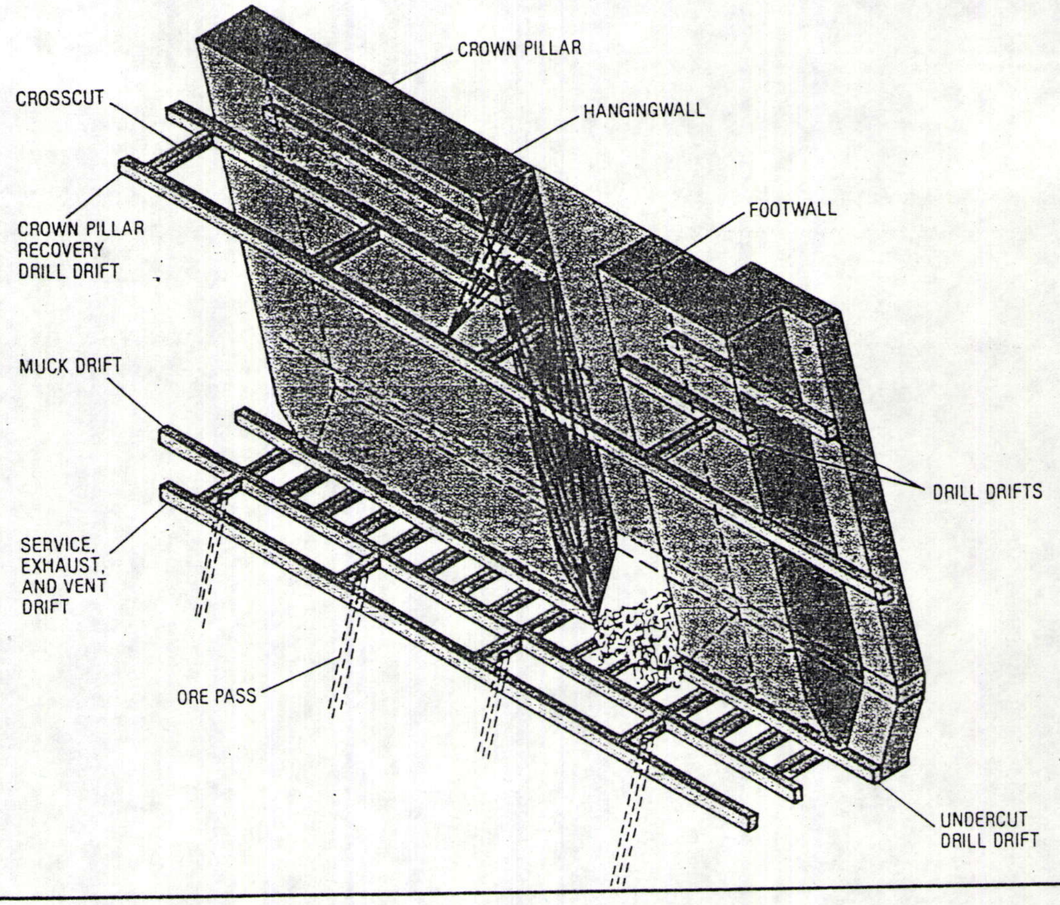
Carr Fork, located adjacent to Kennecott's Bingham Canyon open-pit mine, 25 mi southwest of Salt Lake City, will cost an estimated $216 million and will produce 45,000 to 55,000 mtpy of copper contained in concentrates. One of the very few underground base metal mines developed in the US in the past decade, Carr Fork will make use of a variety of equipment that has come onto the market in recent years. Hagglunds loaders (see cover), five-car shuttle trains, and two-boom Atlas Copco drill jumbos are in use for development, and rubber-tired LHDs will be used for ore recovery. The main haulage system will include two trains of Asea 12-cu-m cars, each train being made up of 18 cars moved by two General Electric 30-ton locomotives. The trains can be controlled from either locomotive, with the second unit responding automatically to the operator's commands. The trains can also be radio-controlled by an operator at the loading chute. The system is being built to conventional US railroad standards.

Conventional blasthole methods may be used to mine the Carr Fork ore, but management is also planning use of Canadian Industries Ltd.'s patented "Vertical Crater Retreat" method. Project manager Art Ditto comments: "This method has been a fact of life for three years. It employs essentially the same procedures we have already anticipated using—nothing different with respect to development, drilling, ore draw, and so on. It's simply a variation, and it has the potential to eliminate some development work and also to utilize explosives more effectively. It has the potential to reduce blast damage throughout the mine and at the same time produce better fragmentation. It's a very significant development."

Because Anaconda management elected to build the concentrator in the steep, narrow canyon where the production shaft headframe is located, designing the plant was "not going to be the easy job of setting it out in the middle of a big field and wrapping a building around it." Mill equipment manufactured to standard English units was one exception to the metric system of measure that Anaconda adopted throughout most of the Carr Fork project.

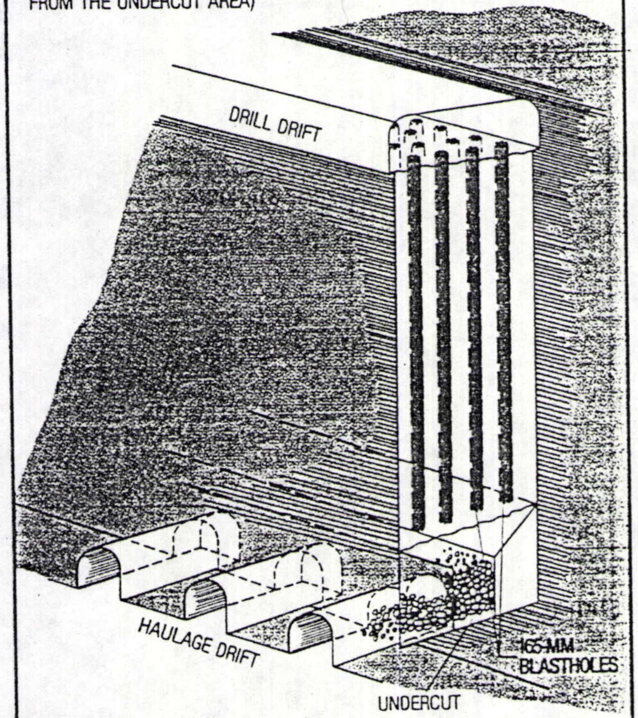
Carr Fork is thought to be the first US mine designed from the beginning around the metric system. Management thinking was that

Carr Fork blasthole mining method



'Vertical Crater Retreat' stoping method

(ORE BLASTED IN HORIZONTAL SLICES, MOVING UPWARD FROM THE UNDERCUT AREA)



the country will eventually convert to metric measure, so starting out with metrics at Carr Fork would be a plus. Conversion at a later date would only create problems, and maintaining a set of records and maps in both English and metric units would be burdensome.

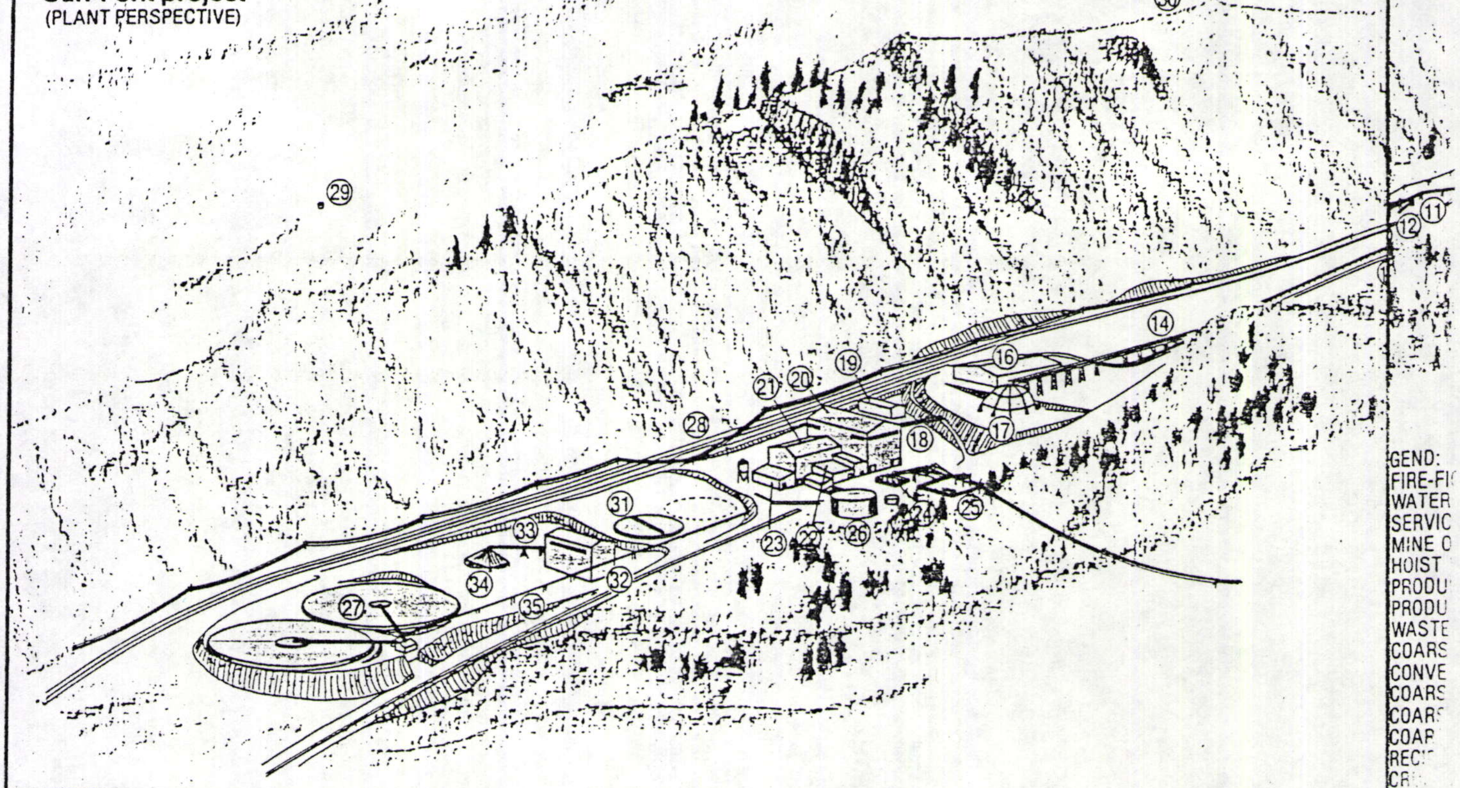
Despite cost escalations and inflation, the Carr Fork project has managed to remain close to budget and on schedule. Cost estimates arrived at in the feasibility study conducted in 1974 have proven to be very close to actual construction costs.

In building Carr Fork, Anaconda philosophy has been to use the services of the employees who will operate the complex. Mining—being an art as well as a science—reflects the experience of all the people involved, the company feels, so those now "on board" will run the project when it comes into production. To offset a serious shortage of underground miners in the project area, Anaconda initiated a "head start" underground miner training program in the spring of 1977—more than two years ahead of the scheduled production date—with trainees receiving four months of classes and practical instruction before going to work in the mine. The program may be expanded in the future to include concentrator personnel.

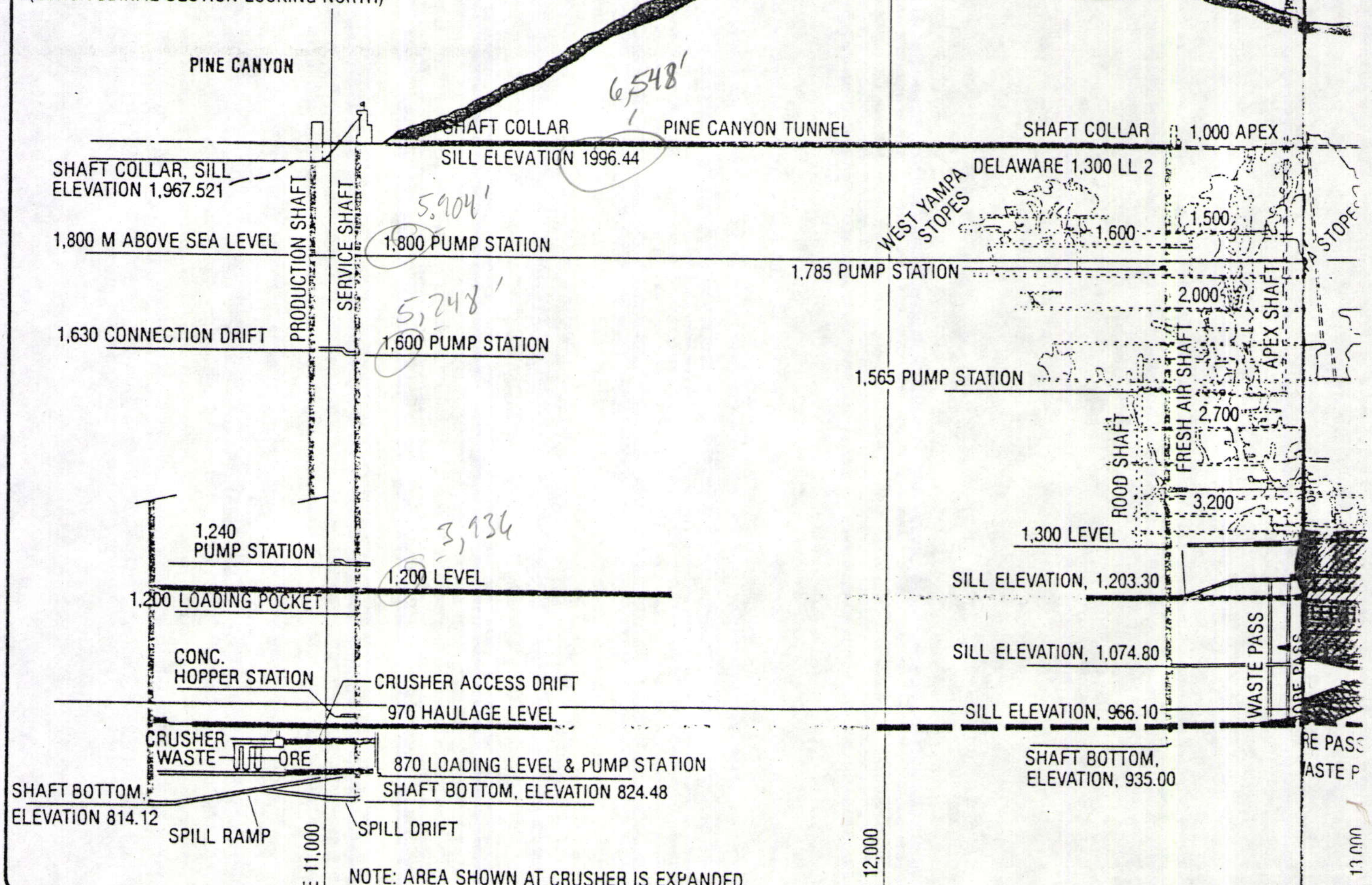
IN BINGHAM DISTRICT SINCE 1914

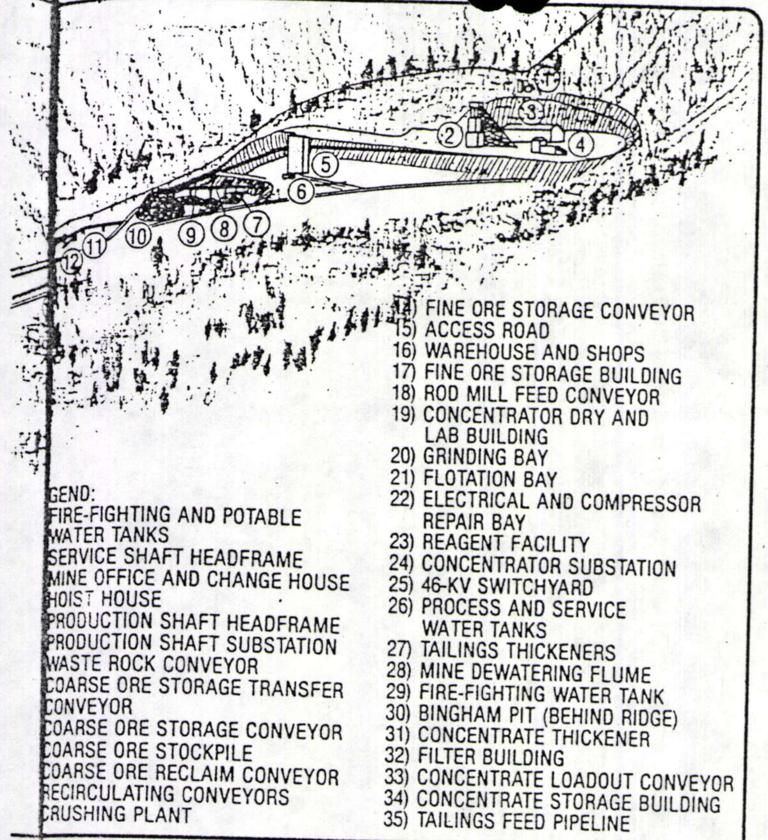
Anaconda, which acquired the Carr Fork property in 1948, has been active in the Bingham district since 1914, when The International Smelting & Refining Co., a subsidiary, built a custom smelter near Tooele, Utah. To establish stable sources of smelter feed, Anaconda acquired interests in various properties and companies in the district, and by the mid-1930s, it held a substantial interest in the area west of the Bingham pit. Five of the companies in which Anaconda had interests subsequently consolidated to form National Tunnel & Mines Co., which developed the first underground copper

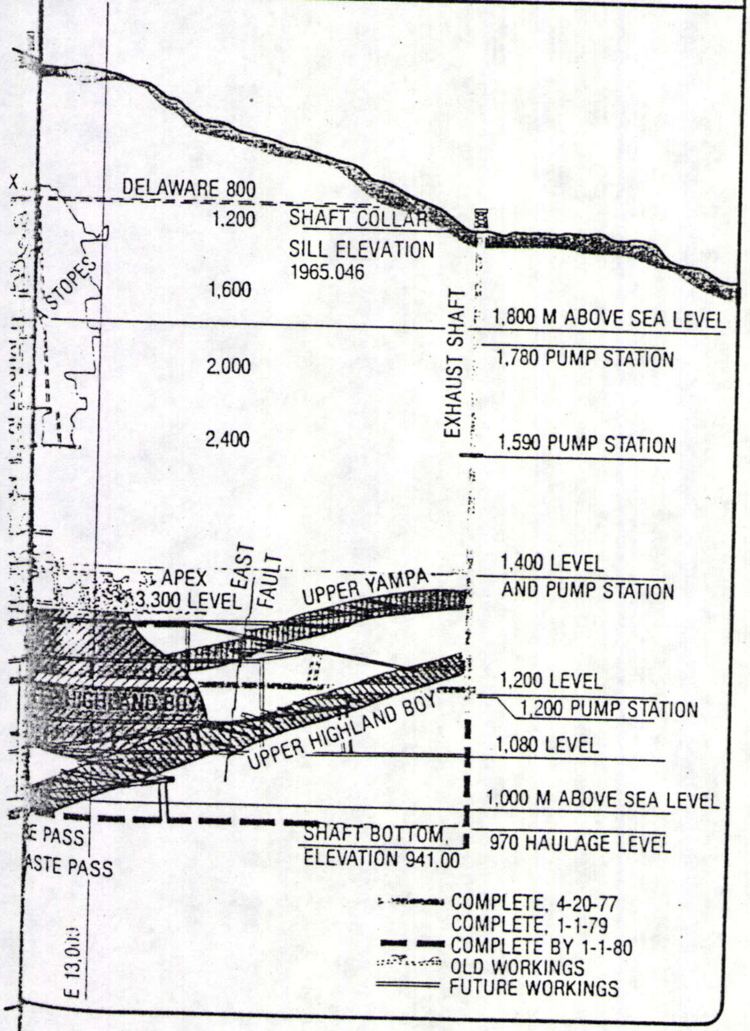
Carr Fork project
(PLANT PERSPECTIVE)



Carr Fork project
(LONGITUDINAL SECTION LOOKING NORTH)







mine in that part of the district.

To transport ore from the Utah-Delaware mine to the International concentrator and smelter, National Tunnel & Mines began driving the 27,000-ft Elton tunnel in 1937, completing the project in 1941. The company continued to operate until 1947. During the next year, Anaconda acquired all of the National Tunnel & Mines assets and lands, including the Carr Fork claims. A 20-year exploration program on the properties eventually prompted extensive core drilling, starting in 1969. By 1973, drillers had delineated the Yampa and Highland Boy orebodies that are the basis of the Carr Fork mine.

The Carr Fork deposits lie under the western flank of the Oquirrh Mountains at a depth of 610 to 1,830 m. The ore is a skarn formed in two limestone units enclosed by quartzites, all of which are Pennsylvanian in age. During the Cretaceous, the beds were folded into a series of northwest-trending asymmetric anticlines and synclines. Later, a multiple intrusive sequence of rocks ranging in composition from quartz monzonites to latites resulted in formation of the Bingham porphyry ore and, presumably, of spatially associated skarn, fissure, and replacement deposits. Subsequent faulting produced a complex structural pattern and several large structural blocks.

The Carr Fork orebodies have average overall dimensions of 900 x 1,000 m, and they exhibit exceptional continuity. There are no unmineralized zones within currently defined boundaries. The two mineralized limestone beds range in thickness from 25 m to 75 m. Dips range from vertical to 20°, and the strike varies from east-west to northeast-southwest. Hangingwall and footwall rocks are generally unmineralized quartzites, with the exception of some minor areas of copper mineralization in the hangingwall. The ore is moderately hard and tough. Waste rock is hard, brittle, and well fractured.

MINE SERVED BY FOUR SHAFTS

Four circular, concrete-lined shafts will service the Carr Fork mine. Three—the production, service, and exhaust air shafts—were sunk from the surface, while the fourth—a fresh air shaft—is collared near the end of the 1,830-m Pine Canyon tunnel (see mine cross section). A Watson four-boom jumbo and two Cryderman muckers were used in sinking each of the shafts.

Shaft-sinking crews bottomed the 5.79-m-dia production shaft at 1,153.36 m in late 1978, with crews from Anaconda and Peter Kiewit & Sons both contributing to the work. The sinking rate, including all stations and delays, was 1.2 m per day. A Nordberg double-drum, double-friction-clutch hoist powered by a 2,250-hp motor was used to sink the shaft.

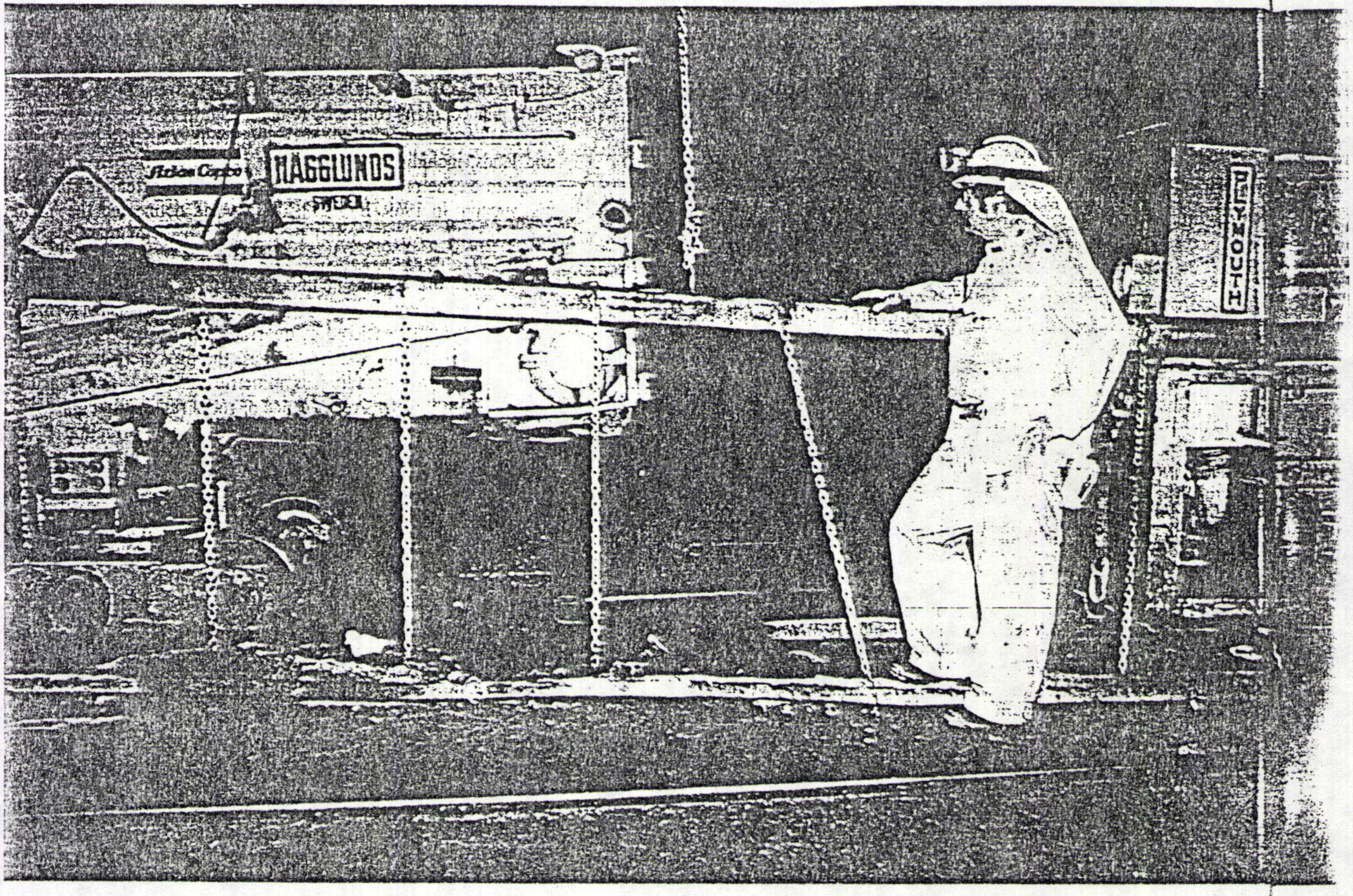
The service shaft is complete to a depth of 1,172 m and is being used to hoist waste as well as men and supplies until the production shaft becomes operational. The 5.79-m-dia shaft is fitted with a 6,000-hp Nordberg double-drum, positive-clutch hoist, a 14.5-mt Lakeshore skip, and a 72-man cage. The hoist speed is 670 m per min.

Anaconda mine planners decided to sink the fresh air shaft internally to reduce costs and to make better use of manpower and equipment. The 5.5-m-dia shaft will be bottomed at 1,070.33 m. The Pine Canyon access tunnel will be used only for air intake and for servicing the shaft.

Thyssen Mining & Construction Co. sank the initial 760 m of the 1,024-m-deep, 6.7-m-dia exhaust air shaft. Sinking of this shaft will resume in 1979, and three axial flow fans eventually will be installed at the collar of the shaft.

970 AND 1,200 MAIN LEVELS

Carr Fork mine development is in progress on main levels at elevations of 970 and 1,200 m above sea level. Drifts advance at the rate of about 7 m per day. The 1,200 level is 4.5 m high x 3.7 m wide and will provide general access to the mine workings. The 970 level is 4.5 high x 4 m wide and will be used for main haulage.



Development equipment on the 1,200 level includes two-boom electric/hydraulic Atlas Copco jumbos; a Hagglunds loader and five-car shuttle train; and two 22.7-mt Plymouth diesel locomotives. ANFO is used for blasting wherever possible, and Ireco 38-mm water gel or 32-mm gel is used in all other cases. A Getman scissor truck is used for loading blastholes.

On the 970 level, equipment now in use includes two 3.8-cu-m Jarvis-Clark LHDs and a two-boom jumbo. In the near future, a Hagglunds loader will replace the LHDs.

An Ingersoll-Rand RBM-7 raise borer will be placed in service to open ore and waste passes and ventilation raises. The first sublevel is now being driven into the Steep Highland Boy orebody by Thyssen Mining & Construction crews.

Future development work to maintain production is expected to average about 11,000 m per year, including drifts, crosscuts, ramps, and raises.

PLANS FOR VCR

In the Vertical Crater Retreat blasting method now planned for use at Carr Fork, in-the-hole drills sink large-diameter holes from the top sill, through the ore, to an undercut draw opening. Spherical explosives charges are placed at a calculated optimum distance above the back, and a horizontal thickness of ore is blasted downward into the undercut area. The procedure is repeated upward until the top sill is reached and blasted into the stope.

Regardless of the mining method used at Carr Fork, blastholes will be drilled 165 mm in diameter using in-the-hole drills. Stope geometry will vary to accommodate the outlines of the orebody. In individual stopes, one or two drill drifts will be opened at the top of the ore, and trackless draw points and an undercut drift will be located 45 m to 50 m below the drill drifts. Stope and pillar dimensions will depend on rock strength. When necessary, mined-out stopes will be backfilled prior to pillar recovery, with fill obtained from development waste and hangingwall cave.

The main pumping system for the mine is still being designed, with eventual flows expected to reach 10,000 liters per min. C-5 and D-5 A-S-H pumps are currently in use underground.

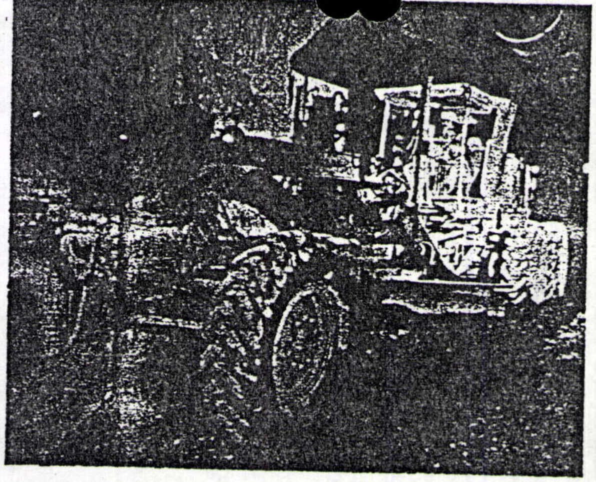
Carr Fork production crews will begin mining near the top of the vertical section of the Steep Highland Boy orebody, advancing along the strike of the mining horizon. Successive sublevels will be worked, moving downward through the orebody. When fully developed, the mine will have three producing areas—the Steep Highland Boy, the Upper Highland Boy, and the Upper Yampa.

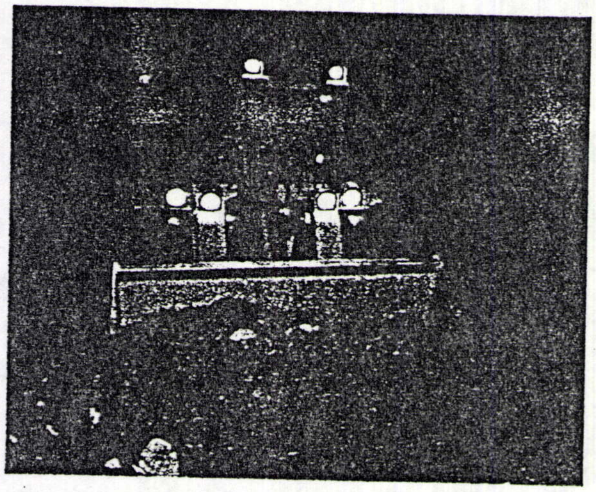
LHDs having 3.8-cu-m-capacity buckets will transfer ore to 2.13-m-dia transfer raises equipped with 0.76-m grizzlies and spaced to limit haulage distances to an average of 100 m one way. Main ore passes will be raised 2.44 m in diameter through competent, unmineralized limestone from the 970 main haulage level. Ore loaded into 12-cu-m bottom-dump cars through wide-mouth arc-gate chutes will be hauled 2,300 m to coarse ore bins.

From the two 600-ton coarse ore bins, muck will feed to a 1.829-m gyratory crusher over a 1.83 x 6.10-m vibratory feeder. Crushed ore will move to two 2,500-ton fine ore bins, and waste will report to a 2,000-ton waste bin. A 48-in. belt conveyor will transfer the material to skip loading pockets on the 970 level.

$60 MILLION FOR MILL TO DATE

Anaconda has invested $60 million in the Carr Fork mill so far, with $11 million going for new equipment. Some equipment was obtained from other Anaconda operations and was rebuilt. Anacon-





Modern equipment provides muscle for Carr Fork's underground operations. Seen here are Hagglunds ore cars, a low-profile road grader, a front-end loader, a jackleg drill, and a shotcrete applicator.

da engineers designed the flowsheet, and Bechtel Corp. is providing construction management. Concentrator superintendent Jeff Butwell, who will manage the plant after startup, has been with the project since it began.

Anaconda considers itself conservative when it comes to designing and building crushing plants, and the company has come up with an extra-husky plant for Carr Fork. Equipment includes Nordberg crushers, Tyler screens, Falk drives, and Jeffrey belt conveyors. Coarse feed to the 7-ft-dia Standard cone crusher is controlled by power draw. Rheostats connected to apron feeds will be adjusted manually by an operator to keep a 200-ton-capacity surge bin full, ahead of screens that are installed ahead of two 7-ft-dia Short Head crushers (see flowsheet).

Three slot-type feeders under a 10,000-ton-live-capacity fine ore stockpile feed to a 36-in.-wide conveyor belt, which is controlled by the feed rate, and the ore then advances to the rod mill. The Koppers Hardinge grinding mills include the 14 x 20-ft rod mill, a 16½ x 29-ft ball mill, and two 9½ x 15-ft regrind ball mills. Krebs cyclone classifiers produce a circulating load of 300% for the ball mill. Estimated steel consumption in the rod, ball, and regrind mills will be 0.70 lb per mt, 0.94 lb per mt, and 0.06 lb per mt, respectively.

Power consumption in the primary grinding circuit will be about 11.5 kw per ton to drive the 2,000-hp rod mill, 5,000-hp ball mill, and 600-hp regrind mill.

The grinding circuit is close-circuited with the cyclones, whose feed density will be measured by an Ohmart density gamma gauge and adjusted by adding water as necessary. Milling and classification will reduce the ore in size to 100 mesh, rather fine for a copper ore but helpful in achieving a 94% recovery rate.

Cyclone overflow will report to a 17-cell rougher flotation circuit comprised of 500-cu-ft cells. Rougher concentrate will then report to the two ball mills in the regrind circuit, and regrind mill discharge will be pumped to four 15-in. cyclones. This cyclone overflow, at minus 325 mesh, will advance to two cleaning stages, the first being a four-cell cleaner circuit and the second being a two-cell recleaner circuit. Flotation cells of 300-cu-m capacity will be used in the cleaner circuits.

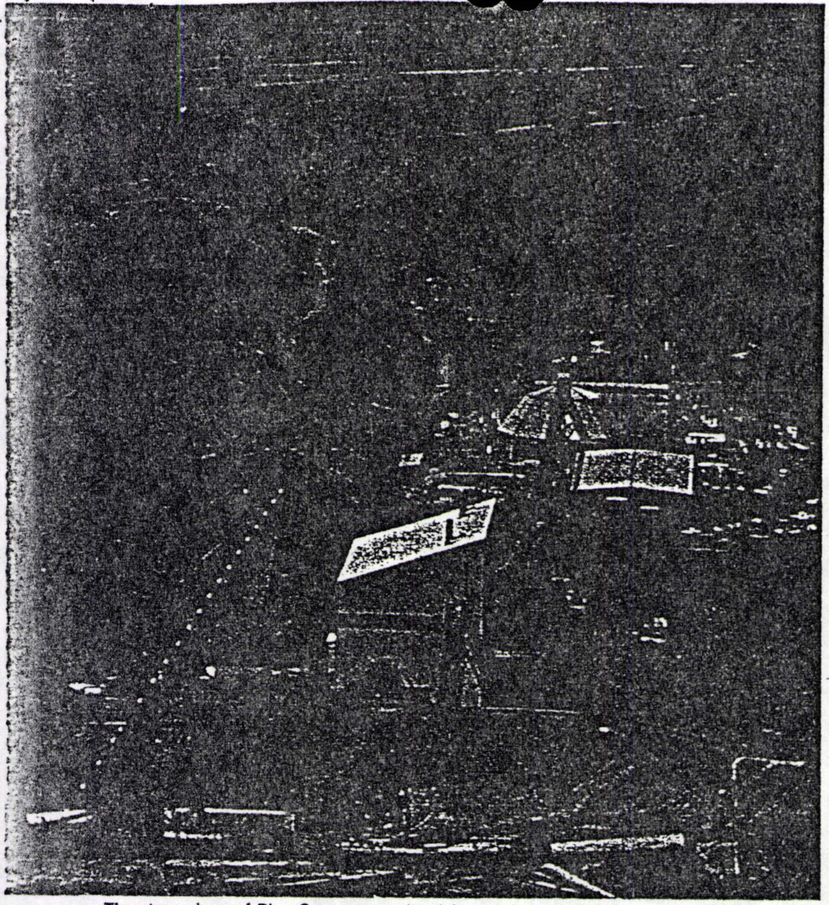
Tailings from the rougher cells will be pumped to three 26-in. cyclones for sand separation. Cyclones overflow will discharge to tailings disposal, while underflow will report to a circuit of five 500-cu-ft sand flotation cells. Sand flotation concentrate will be pumped to the regrind-circuit cyclones by two 8 x 10 Galigher pumps.

Cleaner tailings will flow to six 300-cu-ft scavenger cells, and tailings from this circuit will discharge to tailings disposal. The scavenger concentrate recycles to the regrind circuit.

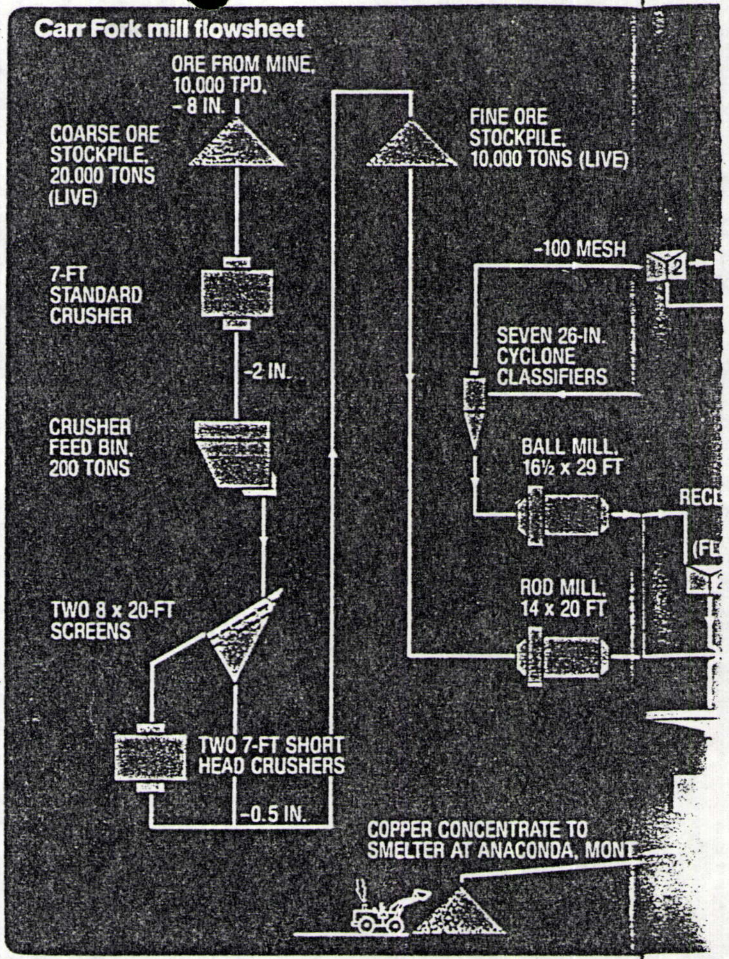
Recleaner concentrate will report to a 125-ft-dia Dorr-Oliver thickener, where it will be thickened to 65-70% solids. Thickener underflow will report to two 20-ft-dia storage tanks equipped with Denver agitators. Moisture in the concentrate slurry will be reduced to 12% by filtration with two 12 x 18-ft Ametek drum filters having a total filtering area of 1,360 sq ft. The filters are equipped for string discharge. Filtercake will be conveyed to a 2,000-mt-capacity stockpile.

Filter tailings will report to two 225-ft-dia Dorr-Oliver tailings thickeners. Overflow will be returned to the mill for reuse, and underflow will flow by gravity through an 18-in.-dia, reinforced-concrete pipeline to the tailings pond for settling.

Concentrate loaded into trucks by a front-end loader will be hauled 9 mi to the main line of the Union Pacific railroad. From there, the concentrate will move by rail to Anaconda's smelter at Anaconda, Mont. Blister copper produced at Anaconda will be



The steep slope of Pine Canyon permitted Anaconda to design an energy-efficient crushing plant and concentrator by maximum use of gravity-based flow.



shipped to the electrolytic refinery at Great Falls, Mont., for further processing.

CARR FORK'S COMPUTERS

Since the beginning of the project, Carr Fork has undergone four computer conversions, starting with a 360 Model 20 and then moving up in size and capability to a 370-115, then to a 370-115 Mod 2, and finally to an IBM 270-138. More than 21 CRT screens installed throughout the complex provide quick access to the computer by the various departments. Furthermore, "This is not the last stage of conversion. We're probably in the middle stage, with two or three stages to go before we reach our peak," says Jerry Johnson, data processing supervisor.

The data processing group services engineering, geology, accounting, office services, personnel, payroll, purchasing, materials control, maintenance, project control, and senior management of all departments. CRTs are scheduled to be installed in the mill and underground for maintenance and operating service.

At Carr Fork, all systems design and programming work is predicated on a "data base" concept that places common data files at the disposal of a variety of users. For example, a single geological data file will be used by employees in the departments of geology, engineering, rock mechanics, and others.

Engineering and project control have access to files that produce PERT (program evaluation and review technique) diagrams, and a procurement program reports the dates when projects must be started and the length of time they will take, the dates when drawings must be complete, and the dates for equipment procurement and shipping.

Major computer programs are developed by Carr Fork personnel, not by data processing specialists. The data base continues to increase, and so, according to Johnson, does demand for computer time.

HEAD START UNDERGROUND

Carr Fork started its first training class in the spring of 1977, and in August of that year, the first graduates received certificates in trackless mining procedures. Eight graduates of the class are currently working full time as miners in mine development.

During the early stages of mine development, contractors were employed. Now nearly all of the miners are Anaconda employees. At startup, the company will need a work force of 800, and, according to a company study, it cannot expect to recruit them from other mining communities. Hiring and training of local residents is now standard practice, and since few of these new employees have underground mining skills, training from scratch is an integral part of the project. Trainees for underground mining are screened carefully, and, on the average, about eight new trainees are selected each month, receiving pay from the start of training. After graduating, they are normally paid the going rate for third-class miners. Progress is regularly assessed for possible promotion, depending both on learning and on available openings.

The curriculum includes four major topics: drilling, blasting, ground support, and mucking. As part of the orientation, sessions are held on mine safety and first aid. Underground training is conducted by three coordinators, one for each shift. After four months of training and two months on the job, most trainees are considered to have the knowledge and the skills necessary for promotion to first-class miners.

Overall, Anaconda feels it has developed a good format for the basic training program, which the company plans to continue for the life of the mine.

The [redacted]er emerges from two (2) cations, (1) the "Pine Canyon Tunne[redacted] and (2) a mine service shaft. The portal of the Pine Canyon Tunnel is located approximately north 12°30' east 1,500 feet from the southwest corner of the SW¼NW¼ of Section 28, T3S, R3W, SLB & M. The tunnel extends upstream from the portal south 83°27' east 147 feet; south 51°19' east 143 feet; south 46°13' east 2,859 feet; south 46°52' east 768 feet; south 26°15' east 157 feet; then south 89°15' east 248 feet to the fresh air shaft. Water from underground mine workings is pumped up the fresh air shaft and discharged into the tunnel. This water emerging from Pine Canyon Tunnel is diverted into a precast concrete ditch through which it is conveyed northwesterly approximately 10,000 feet along the northeast side of Pine Canyon and then by open ditch northwestly approximately 5,000 feet crossing the south half of Section 18, T3S, R4W, to settling ponds located in the northwest corner of the southwest quarter of said Section 18. The service shaft collar is located approximately 17°30' east 1,343 feet from the southwest corner of the SW¼NW¼ of Section 28, T3S, R3W. Water from underground mine workings is pumped up the service shaft and conveyed via buried pipeline approximately 50 feet in a northerly direction. The water is discharged into the same precast concrete ditch as described above for Pine Canyon Tunnel water.

w/4 corner

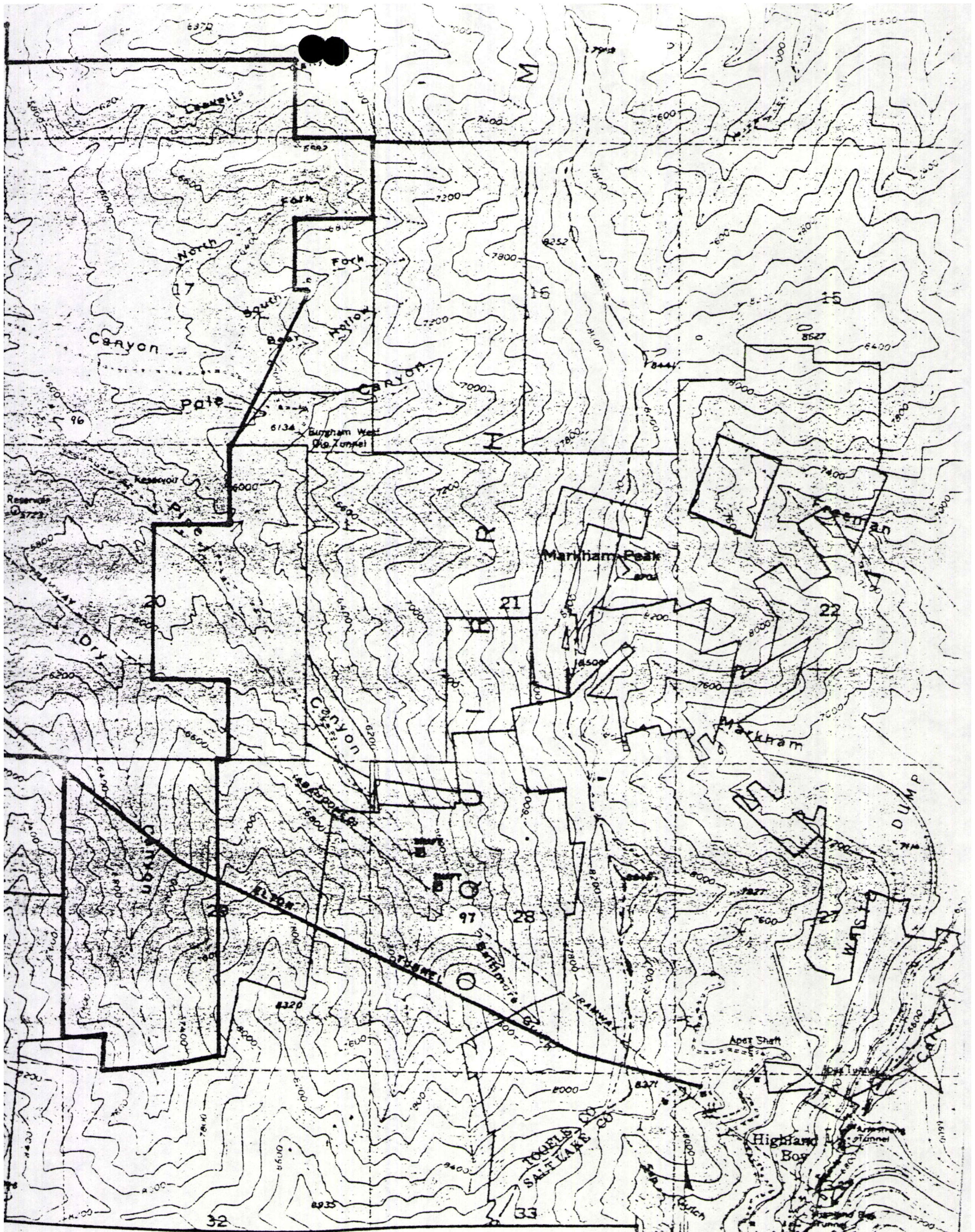
N 17°30' ?

The Pine Canyon Tunnel water and service shaft collar water mix in the precast concrete ditch and follow the aforementioned route to the settling ponds. From the settling ponds there is an open ditch proceeding northwesterly crossing the northeast corner of Section 13, then northerly across Section 12 to the north boundary of Section 12, T3S, R4W. The water transported through this ditch is used for agricultural purposes on land described in paragraph 17. At a point in the precast concrete ditch in the SW¼SE¼NE¼ of Section 20, T3S, R4W, approximately 7,000 feet downstream, northwest of the Pine Canyon Tunnel portal, 4.5 second-feet of water is diverted by means of a flow interception box and transferred via buried line to mill concentrator thickener tanks in the NE¼ of Section 20, T3S, R3W, for use as process water and ultimately is discharged into a tailings impoundment in the NE¼, SE¼ and SW¼ of Section 13, the NW¼ and SW¼ of Section 24, and the NE¼ and SE¼ of Section 23, T3S, R4W.

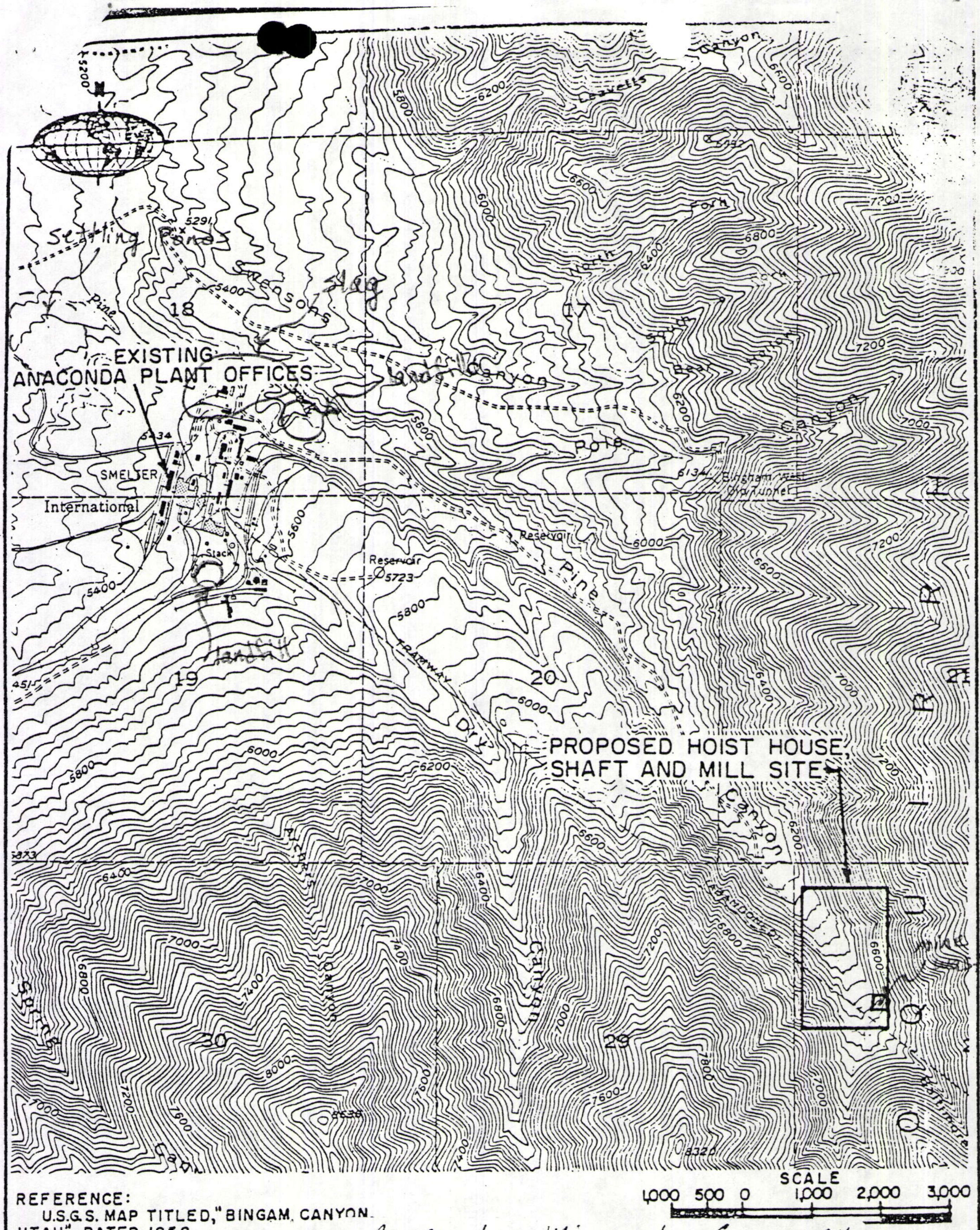
During 1981-1982, the Pine Canyon Tunnel water will be diverted (underground) to the Service Shaft where all mine water will be commonly discharged to the precast concrete ditch.

Water from Pine Canyon Tunnel and Service shaft collar sources not diverted from the precast concrete ditch in the SW¼SE¼NE¼ of Section 20, T3S, R4W for use as industrial process water will be retained for settling in the aforesaid settling ponds. Only one (1) pond is in active operation at any one time, and each pond has ½ acre of surface area and can retain approximately 5 acre-feet of water. Water diverted from the precast concrete at a point approximately 7,000 feet downstream, northwest of the Pine Canyon Tunnel portal, for use as industrial process water is integrated with water existing in the process system, and is not discernible after mixing in the thickener tanks.

In accordance with paragraph 14, 4.5 second feet of water is diverted at a point in the precast concrete ditch in the SW¼SE¼NE¼ of Section 20, T3S, R4W for use as industrial process water each year during the period from January 1 to



E OWNERSHIP (Approximate)



REFERENCE:
U.S.G.S. MAP TITLED, "BINGAM CANYON, UTAH", DATED 1952.

Anaconda Minerals Company

Facilities of Anaconda/Internat. Smelter and waste locations, Carr Fork Project.

8 MOORE

CHECKED BY ____ FILE ____ BY ____ DATE ____